CHAPTER

2

Striving toward reconciliation through the co-creation of water research

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> … abundant material prosperity has come at the expense of unprecedented exploitation of human and material resources and the degradation of the environment. This vision of development comes from a people who have yet to envision an identity and a cosmological connection with the natural world. The vision is generated by an image without substance, technique without soul, and **knowledge without context** [emphasis added]. The crisis we as peoples of this world face may ultimately lead to a social, cultural, and ecological catastrophe. The people of the Americas must come to grips with who they are, develop a spiritual connection with the natural world, and learn to associate with others in a multicultural surrounding. ***(Longboat, 2004, pp. 351–352)***

Indigenous co-creation as an approach to water insecurity in Six Nations of the Grand River

The Haudenosaunee ("People of the Longhouse") of Turtle Island (North America) have a sacred relationship with water. Their ethical relationship, along with their accumulated knowledge, influences and reflects their environmental philosophies on sustainable water management (King, 2007; Ransom & Ettenger, 2001). Although the impacts of colonialism, assimilation policies, and genocide[a,b,c] (Chrisjohn, Young, & Maraun, 2006; Churchill, 1997; Jaimes, 1992; Koch, Brierley, Maslin, & Lewis, 2019; MacDonald, 2019; Martin-Hill, 2008; Ostler, 2019; Smith, 2017; Stote, 2015) have inhibited traditional Haudenosaunee laws from manifesting in contemporary management systems, technologies, and bilateral water governance structures, Haudenosaunee cultural practices and worldviews are resilient. In this context, resilience is an adaptation process that supports the expression of culture and Indigenous identity despite the extreme stressors associated with colonialism and in addition to the management of chronic, daily stressors such as securing access to clean water (Snowshoe, Crooks, Tremblay, Craig, & Hinson, 2015; Supkoff, Puig, & Sroufe, 2012).

Six Nations of the Grand River (hereafter referred to as "Six Nations") is one of the 17 Haudenosaunee communities that was established through the reservation system implemented by settler-colonial governments. The reservation system caused population dislocation, severing of the contiguous traditional Haudenosaunee territory, and disruption of their culture (see Fig. 1). Six Nations is located in southwestern Ontario, along the banks of the Grand River and close to its mouth where it discharges into Lake Erie. The reserve is less than 100 km downstream from major urban centers such as Brantford, Cambridge, Kitchener, and Waterloo. Notably, Toronto, Mississauga, Hamilton, and London are also within 100 km of the reserve[d] boundaries.

Six Nations is the largest First Nations (henceforth termed Indigenous) reserve community by population and is located within the most densely populated region of what is now "Canada." Like many reserve communities, Six Nations suffers from water insecurity. Ironically, despite having an operational state-of-the-art water treatment plant, the infrastructure required to deliver treated water to homes is lacking for the majority of the community (Collins, McGregor, Allen, Murray, & Metcalfe, 2017). Water issues in Six Nations are in part

[a] The Truth and Reconciliation Commission of Canada concluded that Canada committed the following three types of genocide "… in its dealing with Aboriginal people" (Truth and Reconciliation Commission of Canada (TRC), 2015): *physical* genocide, *biological* genocide, and *cultural* genocide. Canadian policies that supported cultural genocide aimed to "… prevent the transmission of cultural values and identity from one generation to the next" (ibid).

[b] The findings from the National Inquiry into Missing and Murdered Indigenous Women and Girls (MMIWG) support the characterization that the human rights abuses perpetrated by Canada—"… both historical and contemporary" (National Inquiry into Missing and Murdered Indigenous Women and Girls, 2019) and enabled by "… settler colonialist structures" (ibid)—amount to genocide, which includes "… violence against Indigenous women, girls, and 2SLGBTQQIA people" (ibid).

[c] See also Article II (b,e) in the Convention on the Prevention and Punishment of the Crime of Genocide.

[d] The Indigenous or "Indian" reserve system was imposed on Indigenous Peoples in Canada to form territorial boundaries and is upheld by Canadian law through the colonial legal mechanism of the Indian Act (1876).

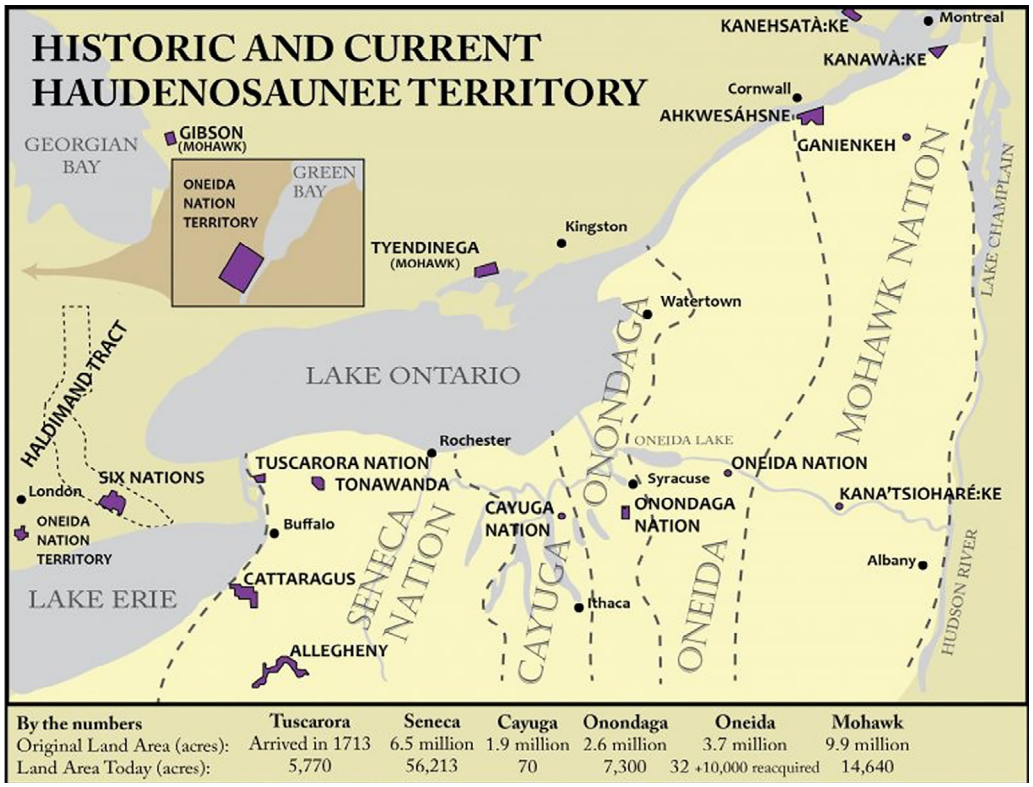

FIG. 1 Historic and current Haudenosaunee territory (Neighbors of the Onondaga Nation, 2013).

linked to the federal government of Canada's inadequate conceptualization and approach to water management for Indigenous communities. For instance, since Six Nations upgraded its water treatment plant, there has not been a community-wide Drinking Water Advisory (DWA) issued, only sparsely distributed individual DWAs for households that have explicitly sought them. As communal DWAs are often used as a proxy to gauge a community's degree of water insecurity (Galway, 2016), the lack of a DWA in Six Nations suggests that most community members have access to a safe and reliable water supply, when the reality is quite different. Water mains from the water treatment plant have primarily only been connected to properties within the village of Ohsweken (Blake Cassels & Graydon, 2001), and thus it is estimated that only 10% of the population have piped water to their homes from the water treatment plant, and less than 30% of the population access this water indirectly through their work or by attending school (ibid.). The remainder of homes must rely on private, decentralized wells or cisterns (Collins et al., 2017)—many of which were not properly constructed or have since fallen into disrepair (Neegan Burnside Engineering and Environmental Ltd, 2005). As a result, some homeowners receive trucked-in water or travel to a local water station to fill up large containers (where the water may then be transferred into the aging and potentially hazardous wells or cisterns), while others are forced to incur the financial and environmental burden and inconvenience of routinely purchasing

bottled water (Duignan et al., 2021). Thus, there is a clear need for the federal government of Canada to provide additional and sustained funding for infrastructural support to improve water security in Six Nations, so long as colonial structures continue to fiscally control Indigenous water governance. Yet the reality of water insecurity at Six Nations falls outside of what Indigenous Services Canada[e] recognizes as their fiduciary responsibility or jurisdiction.[f]

In response to water insecurity and unsatisfactory federal approaches to water management, leaders from Six Nations are working to address the problems that they face by developing innovative and community-based solutions. This includes Six Nations undertaking a leading role in the research project called *Co-Creation of Indigenous Water Quality Tools (CCIWQT)*. This research project is led by a Haudenosaunee woman (Prof. Dawn Martin-Hill, who is both a scholar and a community member of Six Nations); has been community designed and guided from the outset; and encourages the non-Indigenous researchers involved to strive toward reconciliation in all aspects of their research. The project's primary aims are to develop a broadly defined suite of tools that can be used to help address water insecurity and management and to develop these tools through a "co-creation" approach. In the context of this project, co-creation refers to Indigenous and non-Indigenous research being informed by Indigenous and Local Knowledge in the co-production of water management tools.

Carrying out research in accordance with this co-creation methodology was a challenging process for both the Indigenous and non-Indigenous partners involved in CCIWQT. Principally, this approach required extensively educating the non-Indigenous partners on Indigenous issues and approaches and frequent discussions among all parties, including community partners and stakeholders. The process was not always acceptable to all parties, led to occasional conflicts and misunderstandings, and challenged the conventional research approaches of the Western scientists and engineers. Our goal of co-creating research is an iterative work-in-progress and continues to evolve. We do not claim that we have "solved" all the challenges we have encountered, nor that we have found the "correct" approach to co-creating water management strategies. Instead, in this chapter we highlight aspects of this project that address reconciliation; we detail the major challenges that were faced and the lessons learned; we provide points of reflection based on our experiences; and introduce the truly novel "tools" that are in development which have resulted from the process of co-creating water management strategies. More generally, this chapter asserts an overarching notion that the CCIWQT project is challenging the dominant water management paradigm that underpins the Canadian mainstream society's relationships with water by re-establishing an Indigenous water ethic in research through co-creation. In addition, we argue CCIWQT demonstrates that the complex assortment of issues associated with water insecurity in Indigenous communities contains a wide range of opportunities for reconciliation that should be considered and supported by Western scientists and non-Indigenous researchers.

In 2020, Wong et al. published an article that summarized reconciliation approaches for natural scientists. Reflecting the format of the 94 Calls to Action (CTA) within the Truth

[e]See Indigenous Services Canada for more information.

[f]See Roles and responsibilities on the Government of Canada's website for more information.

and Reconciliation Commission[g] (TRC), Wong et al.'s reconciliation approaches have been summarized through the declaration of 10 CTA. Importantly, these calls are designed to be actionable or promotable at the individual level and are specifically targeted toward natural scientists, in contrast to the Calls from the TRC that more broadly describe the need for structural or systemic changes at the governmental or institutional scale and across "… all aspects of Canadian society …" (Truth and Reconciliation Commission of Canada (TRC), 2015). Although this article was published several years after the commencement of CCIWQT, it is relevant to use the structured and defined reconciliation framework articulated and presented by Wong, Ballegooyen, Ignace, Johnson, and Swanson (2020) to analyze and demonstrate the concerted efforts toward reconciliation that have been—and continue to be—undertaken in practice. In this chapter, we have reflected on various aspects of the CCIWQT research and how they address many of the 10 CTA. We have summarized these CTA in Table 1 and references to them will be made throughout this book chapter to highlight how co-creation and community-led projects can be an effective way to tangibly incorporate reconciliation efforts into research.

TABLE 1 Reconciliation Calls to Action for natural scientists working in Canada.

Call to Action	**We call on natural scientists [and engineers]** …
1	… to understand the socio-political landscape around their research sites
2	… to recognize that generating knowledge about the land [and water] is a goal shared with Indigenous peoples and to seek meaningful relationships and possible collaborations for better outcomes for all involved
3	… to enable knowledge sharing and knowledge co-production
4	… to seek out advice from Elders for respectful ways of handling animals [plants, and the environment]
5	… to provide meaningful opportunities for Indigenous community members, particularly youth, to experience and participate in science
6	… to decolonize the landscape … incorporate Indigenous place names as permitted
7	… to take a course(s) on Indigenous history and rights
8	… to call on funding bodies to change approaches to funding [and recognize alternative metrics of progress and success]
9	… to call on editors of all scientific journals to recognize that publication of research on Indigenous Knowledge and cultural resources require review and permission from the respective Indigenous communities
10	[and postsecondary research institutions] … to develop a new vision for conducting natural science: fundamentally mainstreaming reconciliation in all aspects of the scientific endeavor, from formulation to completion

Adapted from Wong, C., Ballegooyen, K., Ignace, L., Johnson, M. J. (Gùdia), & Swanson, H. (2020). Towards reconciliation: 10 Calls to Action to natural scientists working in Canada. Facets, *5(1), 769–783. doi:10.1139/facets-2020-0005.*

[g]See the TRC Website for more information.

While the above 10 CTA were developed by Indigenous and non-Indigenous community members and researchers studying in the Yukon, these are general principles that can help guide all natural scientists (including engineers) working within Canada and on Indigenous territories toward reconciliation. However, the diversity between Indigenous communities and their respective histories and knowledges also calls upon the need to incorporate community-specific approaches to reconciliation and co-creation. With regard to Six Nations, some researchers have discussed how the Kaswentha—a Haudenosaunee wampum belt that was created in the 17th century to document an agreement between the Onkwehonweh (original people of Turtle Island) and the Dutch settlers who were new to the territory[h]—contains principles that encourage many of the reconciliation approaches described earlier. A defining feature of the Kaswentha is that it teaches the importance of preserving a pluralism of belief systems and ways of being, while at the same time needing to protect each system through a form of coexistence defined by non-interference.

In addition to being a general framework for coexistence, several authors have demonstrated how the Kaswentha can be applied to more specific contexts: as an alternative model for environmental cooperation and co-management (Ransom & Ettenger, 2001; Stevenson, 2006); as an ethical framework to decolonize water politics (Stevenson, 2018); as a guide for non-Indigenous researchers for conducting ethical research with Indigenous Knowledge (Duignan, Moffat, & Martin-Hill, 2020; Latulippe, 2015); as a framework for knowledge coexistence (Reid et al., 2020); and as a set of guidelines for Indigenous-University research partnerships (Freeman & Van Katwyk, 2019, 2020; Hill & Coleman, 2018). Notably, the Kaswentha is only one of the several key Haudenosaunee frameworks that is applied to ecological research and practice. For the purposes of CCIWQT, the main teaching from the Kaswentha that has helped inspire the project's approach to co-creation has been to form genuine and strong relationships, but to respect diverse approaches to research. This is particularly relevant for a research program that is both broad in scope and interdisciplinary, but even more so because of the differences between Indigenous and Western research methodologies and knowledge systems.

Thus, with the help of local Haudenosaunee guidance and using the 10 CTA for natural scientists and engineers outlined above, this chapter will summarize aspects of the CCIQWT project and highlight how innovative approaches to water management are striving toward reconciliation.

Scientific research embracing reconciliation

The Co-Creation of Indigenous Water Quality Tools (CCIWQT) project began in the Fall of 2017 and is one of the several Global Water Futures[i] projects that focuses on the "Indigenization and Co-Creation of Research" (Global Water Futures, 2017). From the outset of the project, the non-Indigenous co-investigators and collaborators—most of whom are

[h]For more information on the history of the Kaswentha, see Parmenter (2013).

[i]Global Water Futures is a cutting-edge national research program in Canada funded by the Canada First Research Excellence Fund (see https://gwf.usask.ca/ for more information).

natural scientists and engineers—were mindful of the significance of working with Six Nations during an era of reconciliation, and thus followed the lead of the Indigenous researchers and community partners for navigating how to conduct appropriate and meaningful research. During the inception of the research, and each time there was an adaptation or shift in priorities, the researchers and Indigenous partners discussed, amended, and agreed upon the proposed activities so that the research retained its relevance to, and respect for, the sociopolitical landscape of Six Nations (CTA 1); this therefore made natural scientists and engineers accountable for the impacts of their research.

In the spirit of coexistence and non-interference, CCIWQT was designed to have two primary teams: the Traditional Ecological Knowledge (TEK) team and the Ecosystem Health (EH) team. Research from both teams was community-designed and guided. Priority areas identified by the community for the TEK team included water governance, holistic health, capacity-building, and the incorporation of Haudenosaunee languages (including the use of place names) into research. For the EH team, research priorities related to the cross-cutting issues of drinking water quality, ecological integrity of the local water systems, sensor technologies for environmental monitoring, and how environmental health is impacting members of the community. Notably, while there were distinctions between general areas of focus, there were significant inter- and intra-team integrations and synergies between research activities. The primary distinction between the TEK and EH teams was their research leads such that the TEK team was led by a Haudenosaunee researcher and the EH team was led by non-Indigenous researchers.

For the TEK team that used both Indigenous and Western approaches to research, it was of utmost importance to ensure that the autonomy and completeness (Daes, 1994) of Indigenous Knowledge was safeguarded and upheld. This was achieved by carrying out the Indigenous research methodologies without undue influence from the Western scientists and engineers. To accomplish this, the TEK team was composed of Indigenous researchers supported by the community. Assembling the right team was necessary to provide direction and ongoing support from start to finish.

Here it is important to note that the 10 CTA for reconciliation are *not* targeting the TEK team—a team led by Indigenous researchers who have been fighting for their community and for systemic change within the academy for decades. Instead, we demonstrate how the research activities being carried out by this team embody the CTA for natural scientists and engineers in their reconciliation efforts. Further, the process of co-creation has provided the opportunity for the TEK team to inspire, teach, and facilitate the process of carrying out the CTA by the EH team. In fact, the approach to integrating reconciliation into research via co-creation—and having Indigenous leadership at the helm—could be one feasible way to mainstream reconciliation into the research conducted by natural scientists and engineers (CTA 10). Thus, we have chosen to highlight some of the research conducted by the TEK team for the important purpose of featuring the work's contributions to CCIWQT and Indigenous water management, but also to demonstrate the ways in which the TEK team's methodologies inspired and influenced the research completed by the EH team.

The first featured TEK research activity is directly linked to the 6th Call to Action from Table 1 as it involves the decolonial mapping or "counter-mapping" (Hunt & Stevenson, 2017) of traditional Haudenosaunee territories as a means to reclaim and archive TEK and Indigenous and Local Knowledge. By collecting data and information through research,

meetings, workshops, and community events, *Indigenous* maps of Six Nations are being created to "restore" Haudenosaunee territory and re-story the land and waters that held names which Western colonial cartographers have long ignored and excluded. Part of this includes documenting the linguistic names attached to waterways and water bodies, as language aids in resurfacing the knowledge of the lands and waters that Indigenous peoples have carried with them across generations. Indigenous Knowledge, when taken directly from Indigenous languages, leaves no room for misinterpretation. When the original language is translated into English, the knowledge is taken out of context and becomes vulnerable and at risk for invalidation. To understand the complexity and depth of the relationship Indigenous peoples have with the environment and the water, it is imperative to understand their language. Recognition of the importance of place and language was an important teaching for the Western scientists and engineers that influenced how data and information would be presented by the EH team (to be discussed later on).

The Decolonial Atlas[j] is an online mapping repository that contains a diverse assortment of Indigenous maps. Depicted in Fig. 2[k] is a Haudenosaunee linguistic map created by Jordan Engel that contains the Mohawk names of major urban centers in and around Six Nations of the Grand River. For CCIWQT, the TEK team has assembled a group of knowledge holders and linguists to work with archives and resources (such as Fig. 2) and design a map that will function as a Haudenosaunee living repository of knowledge. Additionally, the TEK team has partnered with several organizations, such as the Amazon Conservation Team[l] and Digital Democracy,[m] to assist in developing the digital Haudenosaunee map, which will house Indigenous Knowledge such as oral histories, traditional land use, ecosystem assessment, waterscapes, and archival data.

The CCIWQT map that is currently in production uses a platform called *Terrastories*.[n] Terrastories is an open access and decentralized digital mapping platform designed for Indigenous communities interested in digitally archiving Indigenous Knowledge that is specific, interesting, important, and relevant to their community. Notably, Indigenous mapping is inherently conscious and inclusive of the human experiences that exist through interactions with the land, water, and environment. For this reason, we believe that the TEK team has provided teachings about reconciliation that go beyond CTA 6. While the use of Indigenous place names asserts Indigenous Knowledge understandings of the environment, *stories* allow for deeper and more personal relational understandings of human and environmental health. Thus, the TEK team's mapping project not only invokes Haudenosaunee place names, but also leverages it as a platform for sharing ecosystem knowledge; knowledge that the EH team has learned is often expressed through stories. Importantly, Terrastories allows for the digital information that is uploaded to be presented in a multimedia format. This promotes the oral exchange of knowledge through functionalities such as directly embedding

[j]See: https://decolonialatlas.wordpress.com/.

[k]Titled "Six Nations in Mohawk" on the Decolonial Atlas. Place names provided by Karonhí:io Delaronde. Map by Jordan Engel. Can be reused under the Decolonial Media License 0.1.

[l]See: https://www.amazonteam.org/.

[m]See: https://www.digital-democracy.org/.

[n]See: https://terrastories.io/.

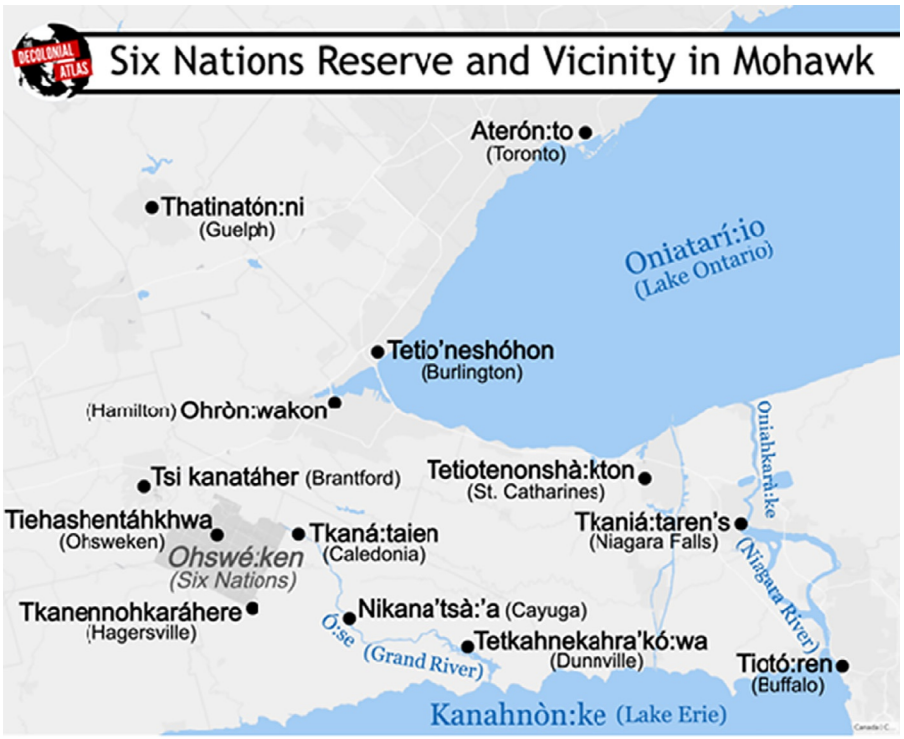

FIG. 2 The linguistic names of Six Nations and urban centers in the surrounding area.

audio and video clips into the map, which also helps to ensure that the story is properly attributed to the speaker (at their discretion) rather than the researchers.

In the context of Haudenosaunee water management, this digital map will help to consolidate the wealth of Haudenosaunee knowledge that has been accumulated over thousands of years through direct observation and monitoring of their waterways. It will also help distribute knowledge and oral stories to a broader audience, which will help sustain and nurture connections to the land and to the community. Indeed, oral storytelling has kept traditional, environmental, medicinal, and cultural teachings or knowledge systems in place for hundreds of years; this project respects and acknowledges that. Since oral storytelling is a key method of knowledge transfer for many Indigenous communities and cultures—including Six Nations and the Haudenosaunee—identifying strategies to create, collect, and collate stories has been a major focus of the TEK team.

Stories are important for how they are able to convey the comprehensive and complex nature of Indigenous Knowledge. Brant Castellano (2000) describes Indigenous Knowledge as being derived from a multiplicity of sources including "… traditional teachings, empirical observation, and revelation." In terms of its characteristics and transmission, there is a measure of consensus that Indigenous Knowledge is "… personal, oral, experiential, holistic, and conveyed in narrative or metaphorical language" (ibid.). Thus, epistemologically, there are

important distinctions and subtle nuances between Indigenous research methodologies—particularly in terms of data collection and analysis—compared to those traditionally used in Western science. The TEK team accounted for such differences in their decision to move away from using conventional academic research terminology. For example, *storytelling*[o]—not *interviewing*—was a strategy that was used to reframe the power dynamic between the "researcher" and "research subject." This is a common Indigenous methodological approach that helps transform research from being a process that is individualistic, self-serving, and extractive to one that is collective, reciprocal, and mutually beneficial (Smith, 2012). Through this approach, the TEK team modeled how decolonizing *research methodologies*—in addition to land and waterscapes—is another way in which reconciliation can be woven into the research process. Moreover, by respecting the principles of the Kaswentha, the EH team was able to learn about the importance and effectiveness of Indigenous methodologies—how, through storytelling, diverse forms of Indigenous Knowledge could be shared with the TEK team; by listening to *both* the lived experiences of community members (empirical observation and revelation) and to the stories that have been passed down to them from previous generations (traditional teachings).

Unfortunately, since 2021, the COVID-19 pandemic has presented major obstacles to sharing stories with CCIWQT and storytelling between community members. Requiring recourse from face-to-face interactions, the TEK team created a social media video production called *Ohneganos: Let's Talk Water* (Let's Talk Water) that facilitates live virtual discussions between Indigenous experts, activists, Elders, leaders, and academics in order to continue the oral transmission of knowledge. Described by the host of Let's Talk Water,

> Indigenous knowledge, stories, and ontologies have informed Haudenosaunee people's reciprocal relationship with, and knowledge of water. Water has been on earth long before humans were created and is connected to all living things; thus Indigenous ways of knowing understand the power of water is beyond the limits of scientific, and even human, comprehension. Let's Talk Water was created to showcase, primarily to community members, that although Western science without wisdom, value, or human connection has resulted in utter destruction and pollution to Indigenous lands and waters, it is vital to have both Indigenous and Western science working together to co-create knowledge that will help to protect life into the future (Direct Communication).

Thus, Let's Talk Water invites Indigenous and non-Indigenous allied community members, researchers, artists, and knowledge holders from Six Nations and beyond into discussion together to share stories, ideas, and knowledge about water (Fig. 3). These live discussions have been recorded and archived and are openly accessible on the Ohneganos Facebook Page[p] and YouTube channel.[q]

[o]To help emphasize the distinction between storytelling and interviewing, the project team worked with a Haudenosaunee language expert to derive the terms Ratiká:raton's (Storyteller) and Ratikararò:roks (Story Gatherer). Tehahenteh (Frank Miller, Six Nations of the Grand River) provided these Mohawk words to the TEK team. These terms were used when carrying out the research activities to help demonstrate that control over the research was in the hands of the storyteller, not the researcher (Smith, 2012).

[p]See: Ohneganos Ohnegahdę:gyo Facebook Page.

[q]See: Ohneganos Ohnegahdę:gyo YouTube Channel for all episodes of Let's Talk Water (and more!).

FIG. 3 Let's Talk Water host Makasa Looking Horse (left panel, center) with a collage of guests.

Not only has Let's Talk Water demonstrated an effective approach to knowledge sharing and knowledge co-production (CTA 3) for the TEK team, but it also acted as a platform that the natural scientists and engineers from the EH team could leverage as well. Since community engagement and knowledge mobilization can often be challenging for non-Indigenous researchers, the TEK team was critical in enabling and facilitating the EH team's engagement in this form of reconciliation. Principally, the TEK team helped structure and develop the episodes (e.g., plan themes and coordinate relevant guest appearances) such that members of the EH team could present their research and engage in lively discussions. Indeed, a number of the individuals depicted in Fig. 3 are members of the EH team who have discussed their research with Six Nations on Let's Talk Water. The entire CCIWQT team is proud of this non-traditional mode of sharing knowledge and storytelling as it has been highly successful in engaging the community, disseminating research findings, and recruiting study participants and partners. Further, it also enabled the TEK team to continue working on their ethnographic mapping research activities[r] during the pandemic. Most importantly, Let's Talk Water has exemplified to community members as well as researchers the true value of bringing Indigenous and Western research together, and how to put science into action at the community level.

[r]See Day et al. (2020) for a similar approach.

In addition to Let's Talk Water, the TEK team leveraged other modes of storytelling that provided access to unique target groups. Though often told orally, stories and personal experiences can also be shared through forms of expression such as creative and visual arts. This is a particularly effective method for learning about and understanding the knowledge and perspectives of youth and children. As a result, on top of digital audio and video recordings, the TEK team documented and shared stories through the facilitation of a community art contest with schoolchildren. The digital exhibit[s] produced—titled *Water is Life*—showcases sixteen original pieces of artwork accompanied by short stories about water (Fig. 4).

The success of the TEK team's art initiative can be largely attributed to our project partners from Six Nations Social Services leading and coordinating the event. This involved recruiting the participants, securing parental consent, and distributing the necessary supplies—steps that all required additional effort in order to ensure that they would be completed in compliance with COVID-19 safety protocols. Six Nations Social Services was invaluable in facilitating co-creation research which heavily relies on local input and participation. Other community organizations (e.g., Six Nations Health Services and the Birthing Centre), their connections to community members, and their established organization systems were essential to many other components of the research. It became evident to the non-Indigenous researchers that community engagement is a key component of Indigenous research methodologies and necessary when navigating a community-led research program, especially during a public health crisis.

The community art contest was one way in which the TEK team provided opportunities for Indigenous youth to "… experience and participate in science" (CTA 5). Although common practice for the TEK team's Indigenous researchers, engaging Indigenous youth in science through an activity such as a digital art exhibition was novel to the non-Indigenous scientists and engineers (and a scientific grant such as Global Water Futures) and demonstrated that culture and innovation should lead the way when involving Indigenous youth in research. Indigenous youth participation opportunities for both teams were facilitated by the TEK team's involvements with youth (which included developing a youth committee) as well as their partnerships with local schools (such as Six Nations Polytechnic STEAM Academy and Kawenni:io/Gaweni:yo Private School).

A final approach to storytelling that was used by the TEK team is a methodology called *digital storytelling*. Technically, digital storytelling is a participatory research method that is used to deliver the creator's narrative by combining multiple sources of information through the use of audio and visual tools. In Indigenous practice, when following the proper community and ethical protocols, digital stories can represent the voice of a community and can be used as a tool to interpret Indigenous Knowledge. Digital stories can also assist in the collection and sharing of Indigenous Knowledge because they align with the conventional Indigenous-preferred means of transmitting knowledge orally. Furthermore, for socially urgent issues that require public awareness—such as Indigenous water scarcity—digital stories can be an effective means for advocacy and promoting change because they have the prospect of reaching a large audience when distributed through social media.

[s]The exhibit can be viewed on the project website at https://www.ohneganos.com/youth-art-exhibit.

FIG. 4 Visual representations of the meaning of water to Indigenous youth in Six Nations.

One innovative strategy the TEK team used to create community-led digital stories involved the youth and children who attend Kawenni:io/Gaweni:yo Private School (KGPS)—the local Haudenosaunee language immersion school. Facilitated through our project partners at KGPS, the TEK team developed workshops to teach students how to make their own digital stories (another example of CTA 5). During these workshops, students worked together to produce three digital stories that were eventually presented back to Six Nations community members and leadership. The three stories created—titled *Water is*

Medicine, *Onekanos—Water Stories*, and *Spiritual Water Story*[t]—are a testament to, *and* product of, the powerful research that was carried out by the TEK team.

Overall, with the introduction of Indigenous mapping, *Let's Talk Water*, the *Water Is Life* digital art exhibit, and the use of digital stories, we have demonstrated how the TEK team focused on *Indigenous* epistemologies, methodologies, and pedagogies throughout their research design. Thus, the work featured above respects and reflects the autonomy that the TEK team has had over managing and conducting their science. Notably, however, this work was challenging because of the amount of additional responsibility the TEK team inherited through the role of guiding the Western scientists as they sought to integrate efforts toward reconciliation into their research practice. The realities and challenges associated with this additional responsibility are described in greater depth at the end of this chapter.

The Ecosystem Health (EH) team, principally composed of a Western science-trained biologist, chemical and environmental engineer, and hydrologist, is focusing principally on environmental science and ecological aspects of water at Six Nations. In the context of water governance, Western science is the knowledge system that primarily manifests within the dominant water management paradigm. CCIWQT recognizes that both Western science and Indigenous Knowledge have important contributions to conservation, environmental management, and scientific research (IPBES, 2019) and that both systems must coexist if reconciliation is to be attempted by natural scientists and engineers. Notably, for many of the Western scientists involved, this project was their first time working with an Indigenous community and conducting research grounded in Indigenous Knowledge. The EH team's Western science-trained researchers bring with them the culture and values of their training. In navigating this new (to them) co-creation approach, the EH team learned to embrace its complementary position as being led within the research relationship and looked to the Indigenous researchers to help guide them through unfamiliar practices, cultures, and territories. This involved a steep learning curve which included: learning about Indigenous Knowledge and the concept of co-creation; understanding and respecting Haudenosaunee protocols, customs, and traditions; and listening and taking direction from community members with respect to how the EH team ought to use its skills and academic capabilities. Thus, all of the research methodologies and activities that were carried out by the EH team were based on Western science but informed by Indigenous and local knowledge (CTA 10).

Concerned with how the integrity of the natural environment is impacting the health of the community, Six Nations leaders worked with the researchers to identify the following four key areas of interest based on the expertise of the EH team's co-investigators: river water quality, climate change's impact on river flooding, home (e.g., drinking) water quality, and water quality monitoring technologies. Knowledge of the environment's water quality, climate change impacts, and drinking water quality were shared interests of the community partners, Elders, and the researchers, which helped foster the development of meaningful research relationships (CTA 2).

[t]Digital stories produced by Co-Creation of Indigenous Water Quality Tools are open access and can be viewed on the Ohneganos Ohnegahdę:gyo YouTube channel.

The first area of interest—river water quality—was the inspiration behind the creek assessment investigation that was carried out over the course of 1 year. The creek assessment monthly sampling program involved collecting water quality information at monitoring stations located along the two main tributaries of the Grand River that flows through Six Nations—the Boston and McKenzie Creeks (Fig. 5). These sampling stations were chosen through consultation with an environmental technician and community liaison, which aligns with the need to seek advice from Elders and community leaders (CTA 4).

The goal of the creek assessment was to quantify the health of the two creeks by measuring water quality using Western science techniques. Thus, water was tested at each station along the two creeks for concentrations of *E. coli*, nutrients, suspended solids, temperature, turbidity, pH, dissolved oxygen, and conductivity. The process of using these parameters as a proxy for stream health (e.g., *E. coli* concentrations are linked to sewage and/or animal's fecal matter and can cause illness or death to humans when consumed) is typical of a Western science study. Distinctive features of these types of investigations include collecting discrete measurements over the course of a relatively short period of time and using standardized quantitative measurements (e.g., water quality guideline concentrations) to assess the safety of the water for humans as well as the health of the creeks for other animal species, such as fish. This study was successful because it was carried out at the direction of the community and in accordance with the community's overall vision for understanding the holistic health linkages between humans and the environment (CTA 2). Based on the findings of the study, Six Nations is now interested in conducting a risk assessment to determine contaminant

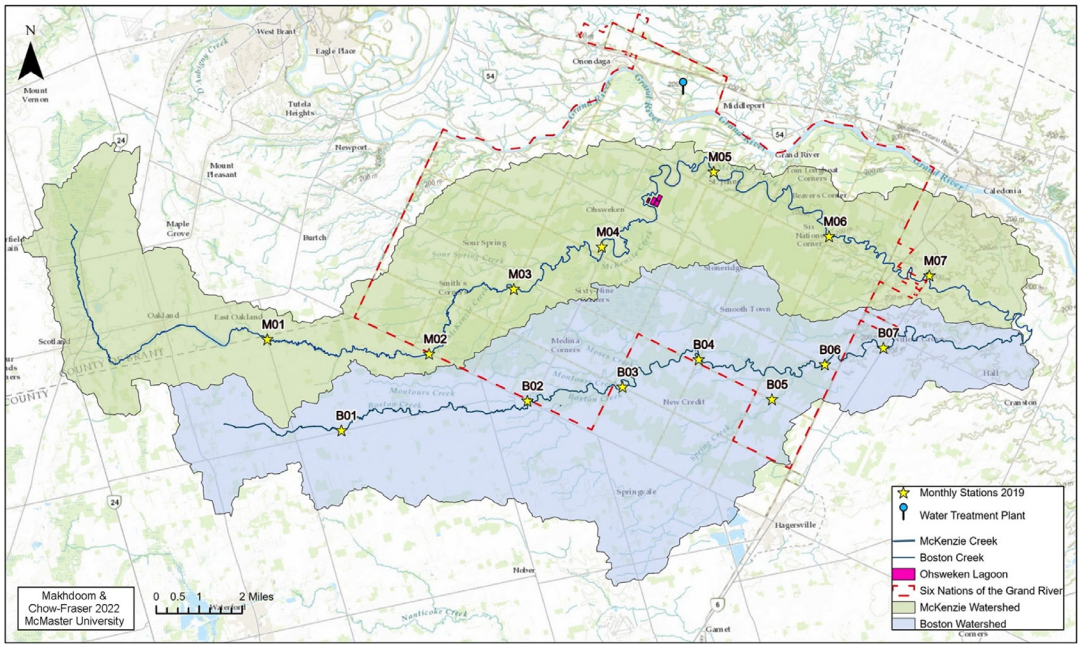

FIG. 5 Locations of river water quality monitoring stations in Six Nations.

exposure pathways and the links between high pollution levels and surrounding land uses and landscape features.

Similarly, at the discretion of the community, the hydrologist on the team focused on climate change modeling, flood mapping, and creek streamflow analysis. This was completed as an approach to understanding the threats and projected impacts associated with climate change and extreme weather events. Western science methodologies were used to model future streamflow and flooding to make predictions on the impact of climate change on the local creeks. For example, the hydrologist utilized "downscaled, bias-corrected Coupled Model Intercomparison Project (CMIP5) data" to determine projected climate extremes and their impact on river water levels and temporal flow patterns. While the specific details of the methodology were mostly irrelevant to our community partners, the outcomes of the model were of great importance and the clear dissemination of these findings was critical. The TEK team helped the EH team distill and summarize the data in a manner that made it more accessible and relevant to Six Nations, ensuring that the community can make practical use of the findings (Fig. 6). In this way, Six Nations has control over the Western science-basedclimate data sets and can leverage them as part of their larger sustainable water management plan (CTA 3).

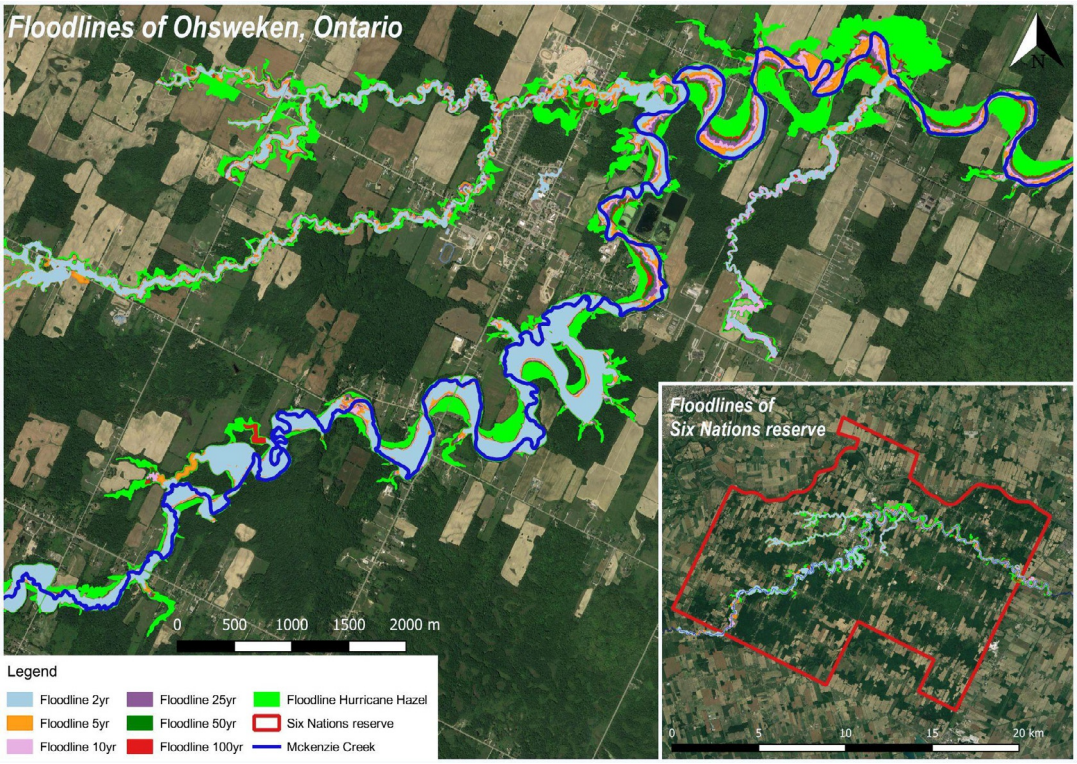

FIG. 6 Floodplain map of Ohsweken visualized by the EH team using data from Six Nations. (The floodline shapefiles that were used in this figure were created during the development of the *Six Nations of the Grand River Territory: McKenzie Creek Master Drainage and Flood Remediation Plan* (Stragis Environmental Services Inc. (Stragis), 2016).)

Community leaders indicated a strong concern over their community's drinking water quality, and thus the EH team also conducted a tap water quality assessment. In discussions between the Indigenous partners, the TEK team, and the non-Indigenous researchers, the EH team decided to investigate if the decentralized drinking water systems (such as groundwater wells and cisterns) within Six Nations were impacted by bacteriological and/or heavy metal contaminants. A subsequent objective was to identify the potential sources of the contamination and to develop mitigation strategies with community members' suggestions and ideas of what might work best for their individual homes (CTA 5). This assessment adhered to a Western science methodology, where discrete tap water samples were taken from households and tested for heavy metals and bacteria. As part of the heavy metal analysis, water samples were analyzed to determine the presence and concentration of a wide range of heavy metals. This study employed a sophisticated analysis technique called ICP-MS (Inductively Coupled Plasma Mass Spectrometry). More importantly, testing for heavy metals was at the direction of the community and based on local knowledge that there was a general concern around the water quality (CTA 2 and 3). Therefore, similar to the creek assessment, through the use of metrics and concentration limits, the tap water quality investigation helped Six Nations assess the risks associated with small-scale drinking water systems on reserve from a Western science lens (Fig. 7).

This research is helping to quantify the extent of water insecurity at Six Nations that exists despite the recent investment in a new water treatment facility. It is hoped that this co-created research will provide sufficient data to obtain tangible commitments from the federal government of Canada to improve water security, while also shining a spotlight on the limitations of a drinking water advisory approach to water management.

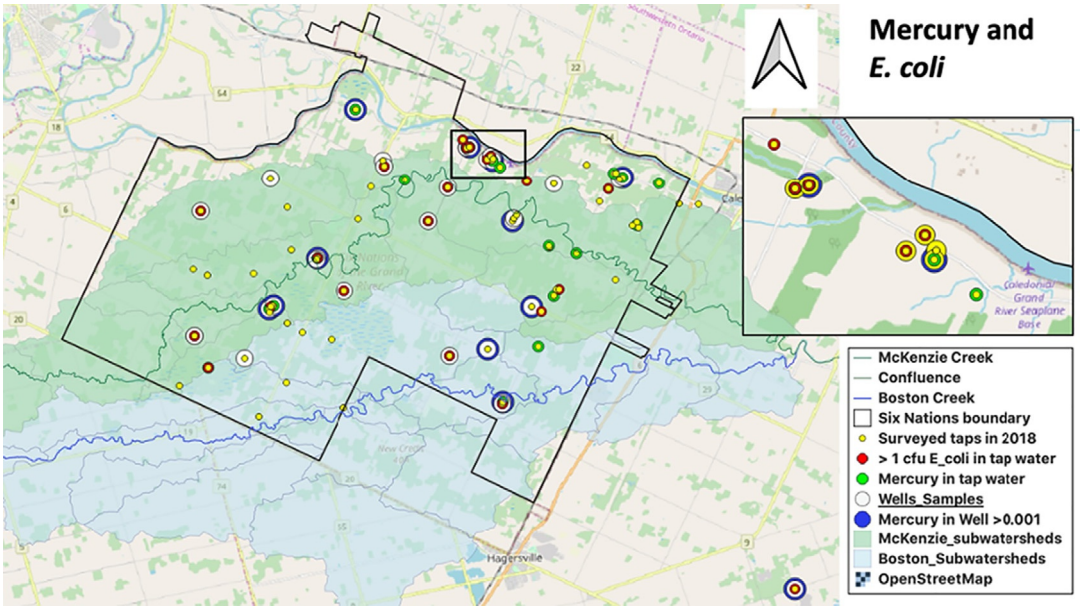

FIG. 7 Results from the tap water quality assessment.

Lastly, as directed by community leaders on the reserve, low-cost sensors are being developed and tested in Six Nations to continuously monitor water quality in two different applications. The first set of sensors includes remote, field-installed devices designed to measure surface water quality. These sensors have been installed in the McKenzie Creek and will be installed in the Boston Creek and the Grand River to monitor for dissolved oxygen, turbidity, temperature, conductivity, pH, and nitrates. To meet the needs of the community and recognizing that the community has limited wireless internet connectivity on the reserve (CTA 1), the EH team used a sensor communication technique that ensured data from all sensor nodes could be accessed using only a 3G connection. This low requirement on broadband wireless access accounts for network connectivity issues within Six Nations, as well as future sensor applications to more geographically remote locations. All the water quality data that is produced will be available to community members to access in real time on a website designed with restrictions determined in collaboration with community members' input. Ensuring that Six Nations has ownership and control over the data helps to address issues associated with data sovereignty on Indigenous territories[u] (CTA 3).

The second set of sensors is designed to measure and monitor the amount of chlorine in drinking water directly from the tap and/or in wells and cisterns. The community requested chlorine sensors that could measure concentrations in real time to improve water security for households threatened by bacteriological contamination. As current technologies that exist for chlorine sensing are expensive or require technical expertise for operation, a simple, low-cost electrochemical sensor was developed (CTA 1). Community-led iterative design resulted in sensors being created whereby users can simply dip the sensor into water from their tap or install them directly into their well or cistern to receive chlorine level readings through a smartphone application. Importantly, these sensors are linked to the creek and tap water assessments that were carried out by other members of the EH team. This key integration is a product of the research being guided by the needs and priorities of the community. Indeed, each application of Western science has been one of several components of a larger holistic vision that Six Nations has for the future of its water management.

The relatively contemporary reductionist objectivism found in Western science stems from the European Age of Enlightenment, a period in time characterized and heavily influenced by the rapid secularization of science in Euro-Western thinking. The perspective that humans are wielders of science who ought to be external observers of the environment has led to a dualism whereby subscribers to this ontology have oftentimes detached themselves from nature. In comparison, Indigenous approaches—such as those incorporated in CCIWQT, particularly by the TEK team—consider the human physical, emotional, and spiritual experiences as integral to the understanding of nature. Historically, such differences between Indigenous and Western knowledge systems and worldviews have resulted in conflicts between Indigenous communities and non-Indigenous researchers (Kovach, 2009). Due to these different perspectives—coupled with an imbalance in power—Western science has often exploited or misrepresented Indigenous communities and Indigenous Knowledge (Castleden, Morgan, & Lamb, 2012). The pressure in research for "progress" can also precipitate ethical violations by Western researchers and academics who are unable or unwilling to

[u]See Schnarch (2004) for a discussion and analysis of self-determination in Indigenous research.

confront differences in approaches. Further, the structures that exist within research organizations (universities, government agencies, hospitals, NGOs, private research firms) do not always hold researchers accountable to acknowledging alternative knowledge, belief, and value systems.

In light of such challenges, the CCIWQT team has recognized that the EH team is able to offer Western science-based knowledge, information, and data that is of benefit to the priorities and needs of Six Nations *when the application of Western science is guided by the community*. For this research project, Six Nations directed how the EH team's methodology was applied within the community. Therefore, despite the negative impact that Western science research has historically had on Indigenous communities, this project's co-creation framework is a case study of how Western science may be "integrated" into an Indigenous-led research project.

"Harmonizing" knowledge production

Many attempts at "integrating" Indigenous approaches with Western science have resulted in the latter redefining Indigenous Knowledge or cherry-picking from it, effectively leading to the assimilation of Indigenous Knowledge into Western paradigms and environmental management structures (Reid et al., 2020; Stevenson, 2006). This form of knowledge integration has been referred to as "cognitive" (Battiste, 2011) or "ontological" (Levinas, 1969) imperialism, where, "… using their artificial tools of classification, the colonizers attempt to Europeanize all knowledge and heritage, even when they are extending beyond their knowledge into the unknown" (Battiste & Henderson, 2000). In the context of Indigenous thought, power disparities between diverse philosophies of knowledge have conventionally forced,

> … aboriginal peoples … to express themselves in ways that conform to the institutions and practices of state management rather than to their own beliefs, values, and practices. And, since it is scientists and resource managers, rather than aboriginal hunters and trappers, who will be using this new "integrated" knowledge, the project of integration actually serves to concentrate power in administrative centers, rather than in the hands of aboriginal people. ***(Nadasdy, 1999, p. 1)***

By addressing the underlying politics of knowledge co-creation, we are able to recognize, "… all knowledge—*including* science—is embedded in larger social processes which give it meaning" (Nadasdy, 1999). In agreement, the Calls to Actions associated with reconciliation (such as CTA 3, 9, and 10) suggest that knowledge should coexist, reversing the tendency for Indigenous Knowledge to be subsumed by Western science. As discussed, this notion of coexistence is also reflected in the general principles of the Kaswentha. Thus, in this case, "harmonization" does not refer to integrating Western science and Indigenous approaches into a single process. Rather, harmonization refers to the two methodologies conducting scientific research independently, according to a common set of guiding principles, in service to community needs and priorities, and with respect to *Haudenosaunee* ontologies and ways of being.

For the Co-Creation of Indigenous Water Quality Tools (CCIWQT) project, knowledge harmonization has resulted in the co-creation of tools that embed the knowledge from each form of scientific inquiry into a dynamic suite of information platforms. Following the priorities of

the community, the tools that have been created are grounded in land and place (through mapping materials) and prioritize an investment in youth and future generations (through education and learning resources). Both the mapping materials and learning resources are planned to further embrace and embody Haudenosaunee Knowledge through the incorporation of local languages and cultural teachings.

The process of mapping has allowed the Traditional Ecological Knowledge (TEK) team to plot the stories, oral histories, and local knowledge information that have been collected within the traditional territory of the Haudenosaunee according to geospatial points of reference. Similarly, the water sensor and sampling data collected and analyzed by the Ecosystem Health (EH) team can be readily mapped, allowing for the Western science data to be superimposed atop the same area of interest. Importantly, complementary data visualization tools are being developed to allow for the Western science information to be more accessible and relevant to community members. Complemented by infusing the Western science knowledge with language and culture, this approach to indigenizing Western science knowledge can be thought of as a form of knowledge translation. Thus, the community partners and CCIWQT team determined mapping to be an innovative method to facilitate knowledge sharing between the researchers and community members (CTA 3)—while placing a strong emphasis on the importance of place (CTA 1).

The second suite of co-created tools, collectively termed "learning materials," principally refers to a science textbook and virtual reality experience (VR) that is being developed with, and for, the schools within Six Nations. Like the mapping platform, both the textbook and the VR act as a canvas to present the distinct knowledge, data, and information collected from the various research activities. The textbook, currently in development at the time of writing, maintains Haudenosaunee ontological underpinnings through following the *Ohén:ton Karihwatéhkwen*[v] and incorporating other culturally specific elements into its structure, such as the Haudenosaunee cycle of ceremonies and matrilineal clan system. Within the science textbook, knowledge from Indigenous and Western approaches will be presented alongside one another, connected through the textbook's structure and via the community-identified topics of interest. In parallel, the VR platform is an immersive experience that places the user on a journey down the Grand River (through both time and space), where they must uncover knowledge, data, and information themselves by interacting with the virtual world (Fig. 8). This is an innovative method of knowledge mobilization, adapting traditional Haudenosaunee pedagogies of land-based and experiential learning to a virtual and digital format. Notably, as a counter-narrative to those who associate Indigeneity with antiquity, most of the co-created tools from this project—which were all informed and directed by community Elders, partners, and stakeholders—leverage the power of modern technology.

The CCIWQT team plans to further consolidate both the mapping resources and the learning materials into a living digital archive (i.e., data portal) that will be made available to community and interest groups, while restricting access to data and knowledge according to the data management protocols outlined by our various community partners, further addressing

[v]The Ohén:ton Karihwatéhkwen (or "words that come before all others"), often referred to as the Thanksgiving Address, is a Haudenosaunee traditional teaching that acknowledges and expresses gratitude for the gifts that nature provides—from the animals, plants, and waters on land to the sun, moon, and stars in the sky.

FIG. 8 Virtual reality learning tool—a journey down the Grand River.

common concerns about data sharing and sovereignty (CTA 3). The broader implications that these tools have toward Indigenous water management primarily involve placing the power over water knowledge back into the hands of the community, while building the capacity of local youth and future generations to ensure they are equipped with the tools necessary to take on future water challenges. These tools are all deliberately designed to be "living" tools, which enables them to be expanded upon by community members and future researchers.

Overall, from the guidance provided by the Haudenosaunee woman leading the project, the non-Indigenous natural scientists and engineers on our team have learned that working closely with Indigenous partners throughout "… all aspects of the scientific endeavor" is instrumental in continually aligning the research with reconciliation goals (CTA 10). When reconciliation efforts and principles derived from the Kaswentha guided knowledge co-creation, science (in particular, Western science) was forced to ground technical research in the experience of the people it served. In effect, this worked to help mitigate "… the experiences and lives of First Nations people, [from being] … compartmentalized … to the categories of scientific management" (Nadasdy, 1999). Yet, despite the successes and insights that have been drawn, the administration and implementation of this approach to co-creation research has not been without its challenges.

The first major challenge was confronted during the project's inception and relates to the politics of knowledge production. Western scientists often have little, if any, comprehension of Indigenous ways of knowing, and this rule held true for many members of the CCIWQT team. As a result, it took a concerted effort to establish dialogical relationships where Haudenosaunee perspectives and approaches to scientific inquiry could be recognized and valued (CTA 1, 2, and 3). The labor involved in familiarizing the research team with Indigenous Knowledge was intensive; this involved the Indigenous researchers having to

teach the Western scientists about Haudenosaunee Knowledge as well as making them aware of Indigenous approaches to science. However, this learning curve was anticipated, as the subjugation of Indigenous Knowledge due to an established hierarchy between knowledge systems is well documented. Described by Shiva (2000),

> … under the colonial influence the biological and intellectual heritage of non-western societies was devalued. The priorities of scientific development … transformed the plurality of knowledge systems into a hierarchy of knowledge systems. When knowledge plurality mutated into knowledge hierarchy, the horizontal ordering of diverse but equally valid systems was converted into vertical ordering of unequal systems, and the epistemological foundations of western knowledge were imposed on non-western knowledge systems with the result that the latter were invalidated (p. vii).

There were a few ways by which Indigenous researchers on the TEK team worked to dismantle the knowledge hierarchy for those involved in the CCIWQT project. One was through an ongoing process of facilitating relationships between the non-Indigenous academic researchers and community members at Six Nations, in particular Elders, Grandmothers, and Knowledge Keepers (CTA 2). Building relationships, *actively listening*, and forming steering committees with community members helped to establish a holistic approach to research whereby direction from the community was embedded throughout every stage of the research process (CTA 10). Community steering committees identified the environmental questions being asked, informed the methods to be used, guided knowledge mobilization efforts, and addressed protocols relating to data sovereignty. Another approach to addressing unequal power relations was through education. The TEK team created a Culture and Ethics Orientation and Training program that was mandatory for all researchers to complete—professors and students alike (CTA 7). This training program helped researchers recognize inherent academic and epistemological biases by focusing on the ethics of working with Indigenous communities, with a strong emphasis on understanding—or at the very least, recognizing, respecting, and learning about—Indigenous Knowledge. Additionally, the orientation also provided an introduction to Haudenosaunee-specific culture and knowledge.

Another significant barrier to carrying out the co-created research arose from the paradox of conducting research led by Haudenosaunee ontologies but being funded by an agency that operates under a Western science research paradigm. We have experienced firsthand the need for CTA 8—the "… call on funding bodies to change approaches to funding." Without changes to funding, the necessary work required to co-create research falls outside the scope of funding initiatives and priorities. Being dedicated to co-creation under a Western science-dominated research funding agency was found to be exceedingly challenging for the research team. This was especially true for the Indigenous researchers, who were tasked with the triple duty of (1) carrying out their own research while (2) facilitating relationships between the community and the non-Indigenous researchers, and (3) ensuring that the Western science approaches were adhering to community directives and Indigenous ontologies. In other words, adhering to the necessary protocols required to conduct respectful community-directed research was difficult to uphold under the constant pressure of the demands and timelines set by federal granting agencies and academic administration. To overcome this difficulty, the project team scheduled regular meetings with one another, as well as events, summits, and symposia with the community partners from Six Nations.

One community-led engagement, *the Haudenosaunee Summit on Climate Change*, was particularly effective in facilitating communication between the academics and the community

partners. The project team attributes the success of this endeavor to our community partners and their Haudenosaunee Knowledge actively working to ensure the alignment of the researchers' directives and goals with those of the community. This was accomplished by bringing the entire team together, reorienting the research within the context of broader social and environmental issues, and reminding the researchers of the community's specific needs and priorities. Indeed, generating substantial research progress without stopping to reflect on or discuss if the research remains aligned with the community's needs is a detriment to the process of co-creation. Failing to communicate routinely and effectively can result in the researcher misinterpreting or assuming the perspectives and priorities of the community and bypassing or overlooking important research collaborations.

Related to this, another challenge experienced by the research team concerned the requirements of the granting agency to structure and evaluate the impact of research scholarship according to Western conventions. For instance, there was a disproportionate emphasis on the importance and expectation of producing academic publications and attending academic conferences compared to other knowledge sharing activities, such as developing informational brochures or attending community workshops and events (CTA 8). Yet, in the context of Indigenous pedagogies, the latter activities are commonly regarded as more significant because of the notion that knowledge is meant to be community-shared, accessible, and put into practice. The misalignment between desired outcomes becomes particularly evident when considering that Indigenous Knowledge is primarily an oral-based knowledge system. The need to produce highly technical publications within hyperspecialized fields of inquiry as a method of sharing knowledge among a group of peers is not the expected mode of dissemination within Indigenous communities and can be seen to isolate the research findings away from community leaders and stakeholders. Further, when these publications are submitted for review, they should be reviewed by Indigenous community members and not only by Western academics (CTA 9).

In recognition of these challenges, it is critical to note, however, that both Global Water Futures and the non-Indigenous Western researchers have spent a considerable amount of time and effort listening to and learning about Indigenous Knowledge—including Indigenous ways of knowing, pedagogies, and knowledge sharing methodologies. The reciprocal responsibility of the natural scientists and engineers to be open to transcending the roots of their own colonial academic biases is not a simple undertaking and is in itself an act of reconciliation. The time and effort that has been committed to this is, at least in part, demonstrated by the willingness to attend training sessions as well as countless meetings, workshops, and events. In fact, the success of CCIWQT can largely be attributed to the dedication of *both* Indigenous and non-Indigenous researchers acknowledging their positionality within the context of co-creation and recognizing the shared goals of the research project (CTA 2). In our view, identifying, managing, and/or overcoming the obstacles outlined above are all necessary tensions affiliated with the process of putting an innovative and community-based co-creation research framework into practice. Through adversity, the natural scientists and engineers have been able to pursue reconciliation *because* of their ability to cooperate and embrace and trust leadership committed to an unfamiliar knowledge system. Ultimately, this has led to the co-creation of Indigenous water quality tools for Six Nations and to the discovery of one interpretation of what it means to "harmonize" knowledge.

Reflections

Through striving for reconciliation, the Co-Creation of Indigenous Water Quality Tools (CCIWQT) research team has been able to develop water management tools that are relevant to Six Nations of the Grand River. Reflecting on this experience has allowed the research team to provide a series of additional recommendations and insights for future researchers looking to carry out co-creation research that works toward reconciliation with Indigenous peoples.

Establishing research principles

The first recommendation would be to introduce the entire research team to the research framework and the general expectations of the community at the very beginning of the project. This includes explicitly describing local teachings and the governing principles that will help guide the research process. In retrospect, this should have been a key component of the project team's Culture and Ethics Orientation and Training program. Despite the omission, the research team would also strongly recommend developing such a training program as it was an effective approach to introducing the Western scientists to Indigenous Knowledge and Indigenous ways of being. Additionally, it provided insight on important research-related concepts, such as Indigenous research ethics and Indigenous data sovereignty. The training program was also complemented with an extensive reading list for researchers who were interested in diving deeper into the content and material. Structures, systems, and resources such as these are invaluable because they help alleviate some of the additional responsibility placed on Indigenous researchers, Elders, and community members, providing them with more time to focus on their own research.

Building community networks

Another recommendation would be to invest heavily in creating a network of community members invested in and committed to the project's research outcomes. The purpose of this initiative is to recruit the appropriate and interested organizational partners and individual collaborators who can provide ongoing direction and an assortment of skills, knowledge, and perspectives on behalf of the community. This can be a time-consuming process, particularly during the beginning stages of a project and especially for Indigenous team members, whose social capital is often leveraged to solidify these research relationships and commitments. Indeed, forming genuine relationships and having the community *lead* co-creation goes far beyond simple one-off conversations or a few hours of consulting with individual community members. As a result, the time, energy, and *resources* required to establish the project's community engagement and commitment are something that needs to be budgeted and accounted for when applying for funding and estimating a project schedule (related to CTA 8). The research team has found that investing time in building a network of engaged community members dedicated to the project is critical because it is the foundation upon which the co-creation research is built.

Maintaining community networks

Importantly, after a community member network is "established," it is also necessary to budget for the time, energy, and resources required to maintain commitments and interest over the course of the project period. This is critical because the community needs to provide direction and contribute their perspective at *every* stage of the research process—e.g., design, training, data collection, analysis, knowledge mobilization, sustainability, legacy (related to CTA 10). For large research programs that span several years—such as CCIWQT—the community network's membership may also experience times of fluctuation and change. Since community members involved in research are often volunteers who may have full-time jobs and/or a series of other commitments to their community, ensuring that researchers manage their expectations helps the team cope between periods of delayed correspondence or when community members are no longer able to contribute their time to the project.

Equitably recognizing contributions

To help sustain the growth and stability within the community research network we strongly recommend recognizing the important contributions of community members. Often overlooked is the fact that Indigenous Knowledge holders and community members are equal (if not *greater*) intellectual contributors on co-creation or collaborative projects, but their involvement seldomly receives equal recognition or accreditation similar to that which is granted to researchers and students studying formally at Western institutions (e.g., Master's, PhD, etc.). To mitigate this inequity and improve the retention of community contributors, the CCIWQT team has been exploring ways in which community members can receive tangible forms of accreditation, such as post-secondary school credits or certificates (related to CTA 5).

Embracing adaptability

Lastly, science is meant to adapt to an ever-changing landscape of knowledge; this holds true when working with Indigenous communities. Navigating decolonization requires patience on all sides and a willingness to remain flexible. It is necessary for researchers to be adaptive and responsive to community needs; this may involve a shift in priorities or a change in research focus. It may also require forming new relationships as research projects progress or if community partners become unavailable. This type of flux can also be beneficial for the research because having a variety of different community members engaged throughout the course of a project can help reveal and account for the diversity that exists within all communities (related to CTA 2 and 3). From a methodological standpoint, this can help reduce research bias and eliminate the Indigenous tokenism that takes place in some research contexts.

Overall, many of the ideas and recommendations noted above culminate in the assertion that patience, understanding, communication, and innovation within the research process are key requirements for successful co-creation and when working toward reconciliation.

To conclude, the CCIWQT project helps contribute to broader understandings of "co-creation" by asserting that "harmonization" is *not* about the amalgamation of scientific

methodologies. Rather, this form of integration is about maintaining good relations between knowledge systems and applying them to the worldviews or perspectives of those whom the science is serving. When a true partnership based on mutual respect and trust is established, both academic researchers and the community are able to benefit. In the context of knowledge coexistence, one distinguishing approach to our research is that it recognizes Indigenous Knowledge as a complete knowledge system without requiring any sort of validation by virtue of it being integrated with Western science; Indigenous Knowledge is sovereign. Respecting Haudenosaunee culture and autonomy (and that of all Indigenous peoples) is thereby preeminent, which means cross-cultural relations and reconciliation efforts are contingent upon this condition. In this way, the merits of Western science get applied without compromising or undermining Indigenous Knowledge (and vice versa). This leads to an alternative and decolonial approach to co-creation that promotes equality and reconciliation when leveraging "… the best from our two worlds, Indigenous and Western" (Hatcher, Bartlett, Marshall, & Marshall, 2009). In our case, with the guidance of our Haudenosaunee partners, the CCIWQT team captured the spirit of the Kaswentha to aid one another and coexist in mutual respect. Through this process, the CCIWQT team used Indigenous and Western approaches to science to co-create water management tools that support Six Nations and its goals of building youth capacity in cross-cultural water knowledge and re-establishing control over its water data. The legacy of these tools will help support Six Nations of the Grand River in its efforts to secure a sustainable clean water future for generations to come.

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